

Prosocial effects of MDMA: A measure of generosity

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Abstract

Background: 3,4-methylenedioxymethamphetamine (MDMA) produces “prosocial” effects that contribute to its recreational use. Few studies have examined the cognitive and behavioral mechanisms by which MDMA produces these effects. Here we examined the effect of MDMA on a specific prosocial effect, i.e. generosity, using a task in which participants make decisions about whether they or another person will receive money (Welfare Trade-Off Task; WTT).

Methods: The project included one study without drug administration and one with MDMA. In Study 1, we administered the WTT to healthy adults ($N = 361$) and examined their performance in relation to measures of personality and socioeconomic status. In Study 2, healthy volunteers with MDMA experience ($N = 32$) completed the WTT after MDMA administration (0, 0.5, or 1.0 mg/kg).

Results: As expected, in both studies participants were more generous with a close friend than an acquaintance or stranger. In Study 1, WTT generosity was related to household income and trait Agreeableness. In Study 2, MDMA (1.0 mg/kg) increased generosity toward a friend but not a stranger, whereas MDMA (0.5 mg/kg) slightly increased generosity toward a stranger, especially among female participants.

Conclusions: These data indicate that the WTT is a valuable, novel tool to assess a component of prosocial behavior, i.e. generosity to others. The findings support growing evidence that MDMA produces prosocial effects, but, as with oxytocin, these appear to depend on the social proximity of the relationships. The brain mechanisms underlying the construct of generosity, or the effects of MDMA on this measure, remain to be determined.

Keywords

MDMA, generosity, personality, individual differences, social behavior, humans

Introduction

3,4-methylenedioxymethamphetamine (MDMA) or “ecstasy” reportedly produces “prosocial” effects, including feelings of empathy for others. In controlled studies it increases feelings of euphoria, wellbeing, sociability and interpersonal closeness (Bedi et al., 2010; Harris et al. 2002; Hysek et al., 2012; Kirkpatrick et al., 2012; Tancer and Johanson, 2001), and MDMA users report using the drug specifically for these prosocial effects (Bravo, 2001; Sumnall et al., 2006). Thus, a better understanding of the cognitive and behavioral mechanisms by which MDMA produces its prosocial or empathogenic effects may provide additional insight into the reasons for the drug’s recreational use. Research on this topic has been limited by the lack of objective tasks to assess these dimensions. In this study, we used a novel task based on evolutionary theories of valuation and welfare trade-offs. This task was designed to measure the tendency to make decisions that increase the welfare of one organism at the expense of another. If MDMA is empathogenic, it should increase the likelihood that subjects will forgo their own welfare to benefit others.

Few studies have examined effects of drugs on generosity. Zak and colleagues demonstrated that the neuropeptide oxytocin increases generosity, using tasks requiring subjects to divide money between themselves and a stranger, or donate to a charity. In one study (Zak et al., 2007), subjects receiving oxytocin (40 IU) were 80% more generous than subjects receiving placebo. In another study (Barranza et al., 2011), oxytocin increased the amount of money subjects donated to charity in a hypothetical

scenario. These findings are relevant to the present study because MDMA is known to increase plasma levels of oxytocin (Hysek et al., 2012; Kirkpatrick et al., 2014a; Kuypers et al., 2014), suggesting that the increase in oxytocin may mediate the empathogenic effects of MDMA (Dumont et al., 2009; Thompson et al., 2010). In another example of “generosity”, Hysek et al. (2014) showed that a recreational dose of MDMA (125 mg) increased the number of prosocial choices in a resource allocation task. Overall, these data suggest that MDMA would also increase generosity in our novel Welfare Trade-Off Task (WTT).

The WTT is a delay-discounting-style task in which participants make a series of decisions about whether they or another person

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will receive money (Delton, 2010; Delton and Robertson, 2012). The task operationalizes generosity as the willingness to trade off personal welfare in favor of the welfare of someone else. Subjects must decide whether (a) another person receives a sum of money and the subject receives nothing or (b) the subject receives a different, usually smaller sum of money and the specific other person receives nothing. A simply put example is: "Will you allocate \$5 to yourself or will you allocate \$10 to your friend?" In order to estimate the Welfare Trade-Off Ratio (WTR), subjects must complete multiple decisions regarding a specific other person where the ratio of the values is manipulated. For instance, across decisions the friend might always have the potential to receive \$10, but the value the subject could receive might vary between \$1, \$5, \$10, and \$15. By doing this, researchers can generate an explicit, quantitative estimate of a subject's generosity to a specific other person.

The WTT is based on earlier research (Jones and Rachlin, 2006, 2009; Rachlin and Jones, 2008a, 2008b) that extended temporal discounting procedures to social discounting. Just as temporal delays can be used to assess a person's temporal discounting parameter ('*k*' in temporal discounting) or the subjective value of delayed benefits, so can social distance be used to assess a person's social discounting parameter. Jones and Rachlin (2006) asked subjects to rate acquaintances by social distance, and found that subjects made interpersonal trade-offs according to the same equation that describes inter-temporal trade-offs.

The WTT is well suited to measure generosity in a laboratory-based study of drug effects. It is sensitive to the relationship with the other person (e.g. friends receive more generosity than acquaintances), allowing researchers to assess drug effects that may differ as a function of social distance. The task has internal reliability (e.g. Cronbach's $\alpha = 0.89\text{--}0.98$) and construct validity (Delton, 2010), as it correlates with several well-understood rating scale measures of similar prosocial constructs. Specifically, it correlates with a rating scale measure of valuing the welfare of close others (i.e. the Communal Strength Scale; Mills et al., 2004), with a rating scale measure of psychological closeness and overlap (i.e., the Inclusion of Other in Self scale; Aron et al., 1992), and with a resource allocation task (i.e., the Social Value Orientation Scale; Van Lange et al., 1997) that has been used previously in a study with MDMA (Hysek et al., 2014).

In the present study, we examine two sets of data using the WTT. First, we administered the task to 361 healthy young adults, without administration of a drug, to provide descriptive information about the task (Study 1). These individuals completed the WTT with regard to both a close friend and an acquaintance, and also completed personality and demographics questionnaires with information about their socioeconomic status. We examined their WTT performance in relation to age, gender, socioeconomic status, and personality. We predicted that trait Agreeableness, which included items related to non-antagonistic and prosocial orientation, would be positively correlated with WTT generosity. Second, we assessed the effects of MDMA (0.5 and 1.0 mg/kg) and placebo on the task (Study 2). Here, the WTT was completed with regard to a close friend and a stranger. We selected a "stranger" instead of an "acquaintance" to test the drug's effects on generosity toward a person who was at a slightly greater social distance from the participant. We predicted that MDMA would dose-dependently increase generosity regardless of the participant's relationship status to the other person. All procedures were approved by the local institutional review board

and in accordance with the Declaration of Helsinki 1975 (and its latest revisions: 2013).

Materials and methods

Study 1: Descriptive data using Welfare Trade-Off Task

Participants. Healthy adult volunteers aged 18–35 were recruited through online advertisements, flyers on community bulletin boards, and word-of-mouth referrals. Inclusion criteria were at least a high school education, fluency in English, and Caucasian ethnicity because this was part of a larger study designed to examine the genetic basis of a range of mood, cognition, and behaviors. Subjects underwent a brief psychiatric screening interview, and subjects who reported symptoms suggestive of any DSM-IV Axis I disorder, including substance use disorders, were excluded. Subjects currently taking any medications were also excluded.

In total, 361 volunteers (57% female) completed Study 1. They were mean \pm SD 23.2 ± 3.3 years old and had completed 15.4 ± 1.7 years of formal education. Women were significantly younger than men (22.8 ± 0.2 and 23.7 ± 0.3 , respectively: $t(359) = 2.3$; $p < 0.05$) but the women and men did not differ in education. Additionally, 344 participants regularly drank alcohol (7.1 ± 5.2 drinks/week), 49 currently smoked marijuana (38 reported at least one occasion per week; 11 reported daily use), and 50 participants were daily tobacco smokers (9.1 ± 9.0 cigarettes/day).

Design and procedure

Participants completed questionnaires and tasks during a single visit to the laboratory. They were instructed to consume their normal amounts of caffeine and nicotine but were instructed to abstain from alcohol for 24 hours, marijuana for 7 days, and other recreational drugs for 2 days before the session. Upon arrival to the laboratory, breath alcohol levels (Alco-Sensor III Breathalyzer, Intoximeters Inc., St Louis, MO) and urine tests were obtained to verify compliance with the drug non-use instructions. The experimental session included other measures, and lasted approximately 4 hours. Subjects were paid for participating.

Measures

Personality. The Neuroticism Extraversion Openness-Five Factor Inventory (NEO-FFI; Costa and McCrae, 1992) was used to assess personality traits according to the Five Factor Theory of Personality. It consists of 60 items using five-point Likert ratings (1 = strongly disagree to 5 = strongly agree), which are designed to assess personality along five scales (Neuroticism, Extraversion, Openness, Agreeableness, and Conscientiousness; 12 items each). Responses to each scale were summed and so scores ranged from 12–60. We predicted that Agreeableness would be positively correlated with WTT generosity and that Neuroticism, Extraversion, Openness, and Conscientiousness would be unrelated to WTT generosity.

Socioeconomic status. Participants were asked to estimate their annual household income on a 21-point Likert scale in US\$10,000 increments. One end of the scale was labeled "<\$10,000", and the other end was labeled ">200,000". For this

Table 1. A sample set of Welfare Trade-Off Task decisions used to create a welfare trade-off ratio.

	You	Other
Option 1	54	0
Option 2	0	37
Option 1	46	0
Option 2	0	37
Option 1	39	0
Option 2	0	37
Option 1	31	0
Option 2	0	37
Option 1	24	0
Option 2	0	37
Option 1	17	0
Option 2	0	37
Option 1	9	0
Option 2	0	37
Option 1	2	0
Option 2	0	37
Option 1	-6	0
Option 2	0	37
Option 1	-13	0
Option 2	0	37

analysis, we split participants into four income groups based on relatively equal group sizes: less than \$20,000 ($N = 102$); \$20,000–\$40,000 ($N = 95$); \$40,000–\$80,000 ($N = 80$); > \$80,000 ($N = 84$).

Welfare Trade-Off Task. This computerized delay-discounting-type task was designed to measure the point at which an individual will switch from a decision that is beneficial to her/his personal welfare to a decision that is beneficial to the welfare of another person. Participants named two individuals (for this study: a close friend and an acquaintance) and, for each individual, answered six series of questions in which they chose to allocate a certain amount of money to themselves or give a certain amount of money to the other person (for example, “Would you rather receive \$24 or give the other person \$37?”). All decisions were hypothetical; no actual money was earned or lost as result of participants’ decisions. For each of the six series of questions, the monetary amount to be given to the other person was “anchored” at a single value. The anchors for the six sets were the same as used in Delton (2010): \$19, \$23, \$37, \$46, \$68, and \$75. The monetary amount to be received by the participant was systematically varied to create 10 WTRs (from -0.35 to 1.45 in ascending 0.20 increments; these are simply the ratios between the amount for the self and the amount for the other). Table 1 shows one set of WTT decisions used to create a WTR. The two dependent variables are the ratios at which the participant switches from choosing to receive the money to giving the money to the Close Friend and the Acquaintance. For instance, if the participant chooses to receive \$24 rather than give the other person \$37 (implying a WTR smaller than $.65$), but then chooses to give \$37 instead of receiving \$17 (implying a WTR of at least $.45$), the ratio at which the participant switched is $.55$, the midpoint between the two question ratios. If the participant does not switch and chooses to

always receive the money, she/he scores the minimum WTR (-0.45). Conversely, if the participant chooses to always give the money to the other person, she/he scores the maximum (1.55). Greater levels of generosity are operationally defined as higher WTR “switch points” (Delton, 2010). In a simple example, if a person has a WTR of 0.50 toward a friend, then that implies they would be willing to trade off up to \$10 if their friend could receive \$20. If the WTR was instead 0.25 , then that implies that they would be willing to trade off up to \$5 if their friend could receive \$20. Overall, this task takes approximately 2–3 minutes to complete.

Data analysis

We conducted a paired t -test to test whether individuals were more generous to the Friend than to the Acquaintance. To investigate individual factors that may influence generosity, we conducted two multiple regressions: one for each dependent variable (the welfare trade-off switch points for Friend and for Acquaintance). Because our goal was to investigate the influence of each individual independent variable while controlling for all other variables, all eight predictors were entered into each model using the forced entry method. The predictors were the three demographic variables (Sex, Age, and Income group) and the five trait personality variables (Neuroticism, Extraversion, Openness, Agreeableness, and Conscientiousness). We also conducted follow-up regression analyses using stepwise methods (both forward and backward) to identify the most parsimonious model for each dependent variable and to verify the significant relationships between the predictors and the outcomes derived from the full models. For all analyses, p values were considered statistically significant at < 0.05 .

Study 2: Effects of MDMA on Welfare Trade-Off Task

Participants. Healthy men and women, aged 18–30, who had used MDMA 4–80 times in their lifetime, participated. They were recruited via newspaper, community bulletin board, and online advertisements. Potential participants underwent an in-person psychiatric evaluation and medical examination, including an electrocardiogram and physical examination. Inclusion criteria were at least a high school education, fluency in English, and BMI 18–30. Exclusion criteria included smoking more than 10 cigarettes per day, night shift work, and any significant medical or psychiatric condition (e.g. cardiovascular, neurological, or major psychiatric illness, including all Axis I disorders) that would increase risk for study participation.

Participants were told that the purpose of the study was to evaluate individual differences in drug response. They were told they could receive a stimulant (such as amphetamine or ecstasy), a sedative (such as Valium), a cannabinoid, or placebo. Participants were instructed to consume their normal amount of caffeine, but were asked to refrain from tobacco use for 9 hours, and other drug use for 48 hours, prior to each session. Women who used hormonal contraceptives were tested regardless of menstrual cycle phase, but women not using hormonal contraceptives were tested only during the follicular phase (days 2–14; White et al., 2002). The study was approved by the Institutional

Review Board at the University of Chicago in accordance with the Code of Federal Regulations (Title 45, Part 46) adopted by the National Institutes of Health and the Office for Protection from Research Risks of the US Federal Government. Participants provided written informed consent prior to participation and after completing all sessions they were debriefed to explain the study.

In total, 32 volunteers (nine female, 23 male; one Asian, five Black, five Hispanic, one Mixed, 20 White) completed the study. They were mean \pm SD 24.9 \pm 3.7 years old and had completed 14.8 \pm 1.2 years of formal education. They had used MDMA a mean of 17.0 \pm 19.3 times (range 4–75 lifetime). Additionally, 31 participants regularly drank alcohol (10.2 \pm 7.3 drinks/week), 27 drank caffeinated beverages (1.6 \pm 1.0 cups/day), 14 currently smoked marijuana (8.9 \pm 8.5 days/month), and seven were daily tobacco smokers (4.4 \pm 3.7 cigarettes/day).

Design

The study used a within-subjects design in which subjects received two doses of MDMA (0.5 and 1.0 mg/kg) and placebo. Participants weighed on average 72.1 \pm 13.1 kg and therefore the average MDMA doses were approximately 36 and 72 mg. After an initial orientation session, participants completed three outpatient sessions separated by at least 5 days as a washout period. In each session participants ingested a single capsule (placebo or MDMA). Dosing order was randomized.

Procedure

Sessions were conducted between 09:00 and 13:30. Upon reporting to the laboratory, participants provided urine and breath samples to confirm abstinence from alcohol (as measured by an Alco-Sensor III Breathalyzer, Intoximeters Inc., St Louis, MO), amphetamine, cocaine, and opiates (as measured by urine toxicology: Ontrak TesTstik, Roche Diagnostic Systems Inc., Somerville, NJ), and marijuana (as measured by a saliva test: Oratect, Branan Medical Corp., Irvine, CA), and women were tested for pregnancy. Sessions were rescheduled if the participant tested positive for drugs.

At 09:30, participants ingested capsules containing either MDMA or placebo. Physiological and subjective measures were obtained at 10:30, 11:00, 11:30, 13:00, and 13:30. The WTT was completed at 11:00. Data collected at other times—which involved other measures not relevant to the present research—will be reported in other papers. During times when no measures were scheduled, the participants were allowed to relax and watch movies or read. At 13:30, participants were discharged provided that their heart rate and blood pressure had returned to baseline levels.

Measure

Welfare Trade-Off Task. We used a similar version of the task to that in Study 1, except that the other person was designated as a ‘stranger’ in order to examine the effects of MDMA on generosity toward a person who was at a greater social distance from the participant. We continued to ask about a friend. Post hoc comparisons of generosity toward the acquaintance in Study 1 with generosity toward the stranger in Study 2 revealed similar welfare trade-off switch points.

Drug

Drug conditions were administered in randomized order, under double-blind conditions. Capsules were prepared by the University of Chicago Hospitals investigational pharmacy. MDMA powder (0.5 and 1.0 mg/kg) was encapsulated in size 00 opaque capsules with lactose filler. Placebo capsules contained only lactose. These MDMA doses were selected based on our previous studies indicating that the drug reliably increases positive mood and alters emotional processing at similar doses (Bedi et al., 2009, 2010; Kirkpatrick et al., 2014b; Wardle and de Wit, 2014).

Data analysis

To characterize the acute effects of MDMA on generosity, WTT switch point data were analyzed with a repeated measures analysis of variance (ANOVA) with two within-subject factors. The within-subjects factors were Drug Dose (placebo, 0.5 and 1.0 mg/kg MDMA) and Person (Friend, Stranger). In order to assess possible sex differences in MDMA responses, Participant Sex was included as a between-subjects factor. Following significant main effects or interactions, post hoc comparisons (one-tailed *t*-tests) were conducted to compare mean responses between the doses (placebo versus all active MDMA doses, and 0.5 mg/kg versus 1.0 mg/kg MDMA).

For all analyses and comparisons, *p* values were considered statistically significant at < 0.05 .

Results

Study 1

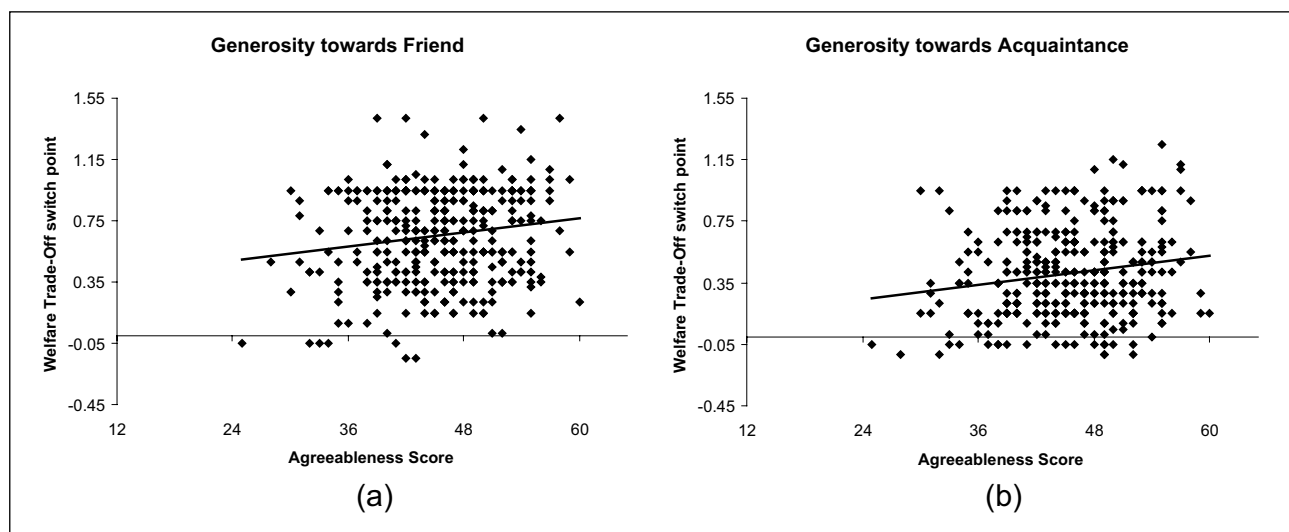
Welfare Trade-Off Task. Overall, participants were more generous toward the Friend compared to the Acquaintance (0.65 \pm 0.02 versus 0.41 \pm 0.02; $t(359) = 17.4$; $p < 0.001$). Table 2 provides parameter estimates for both full regression models. The full model for generosity toward the Friend was non-significant ($F[8,360] = 1.5$, $p = 0.17$, $R^2 = 0.032$). Follow-up analyses revealed that the most parsimonious significant model for the Friend included Agreeableness only ($F[1,360] = 8.7$, $p = 0.003$, $R^2 = 0.024$). The full model for generosity toward the Acquaintance was significant ($F[8,360] = 2.6$, $p = 0.009$, $R^2 = 0.056$). Follow-up analyses revealed that the most parsimonious model for the Acquaintance included Agreeableness and Income group only ($F[2,360] = 8.5$, $p < 0.001$, $R^2 = 0.046$).

Figure 1 shows individual welfare trade-off switch points as a function of Agreeableness score. Higher Agreeableness was associated with greater generosity, and this effect was evident whether the other person was a close friend or an acquaintance. When the other person was the Friend, switch points increased by 0.006 points for each Agreeableness point, controlling for all other variables (Figure 1 (a) and Table 2; 95% confidence interval (CI) 0.000–0.012; $t(360) = 2.1$; $p < 0.05$; Intercept B = 0.133). That is, if their friend could receive \$100, a person with the lowest possible Agreeableness score would trade off up to \$41, while a person with the highest possible Agreeableness score would be willing to trade off up to \$70 (\$29 more). Similarly, when the other person was the Acquaintance, switch points were increased by 0.008, controlling for all other variables (Figure 1 (b) and Table 2; 95% CI 0.003–0.013; $t(360) = 3.0$; $p < 0.005$; Intercept B = 0.287).

Table 2. Parameter estimates for the full regression models from Study 1.

Generosity toward:	Predictor	B	SE	t	p
Friend	Sex	-0.007	0.034	-0.213	0.832
	Age	-0.002	0.005	-0.367	0.713
	Income	-0.010	0.015	-0.689	0.491
	Neuroticism	0.001	0.002	0.296	0.768
	Extraversion	0.002	0.003	0.846	0.398
	Openness	0.003	0.003	0.962	0.337
	Agreeableness	0.006	0.003	2.141	0.033*
Acquaintance	Conscientiousness	0.002	0.003	0.664	0.507
	Sex	0.022	0.033	0.671	0.503
	Age	-0.008	0.005	-1.594	0.112
	Income	-0.038	0.014	-2.684	0.008*
	Neuroticism	0.000	0.002	-0.120	0.904
	Extraversion	0.002	0.002	0.828	0.408
	Openness	-0.001	0.003	-0.270	0.787
	Agreeableness	0.008	0.003	2.975	0.003*
	Conscientiousness	0.000	0.002	-0.139	0.889

*Significant values ($p < 0.05$)

**Figure 1.** Scatter plots and linear fit lines of welfare trade-off ratio switch points for (a) the Friend and (b) the Acquaintance as a function of trait Agreeableness scores.

That is, if their acquaintance could receive \$100, a person with the lowest possible Agreeableness score would trade off up to \$14, while a person with the highest possible Agreeableness score would be willing to trade off up to \$52 (\$38 more).

Figure 2 shows that individual welfare trade-off switch points were also related to Income. When the other person was an Acquaintance, switch points were negatively related to Income group (Table 2; $B = -0.038$; 95% CI: -0.067 to -0.010 ; $t(360) = 2.7$; $p < 0.01$), indicating that participants with a lower household income were more generous to an Acquaintance. That is, if their Acquaintance could receive \$100, participants in the lowest income group were willing to trade off approximately \$11 more than participants in the highest income group. This relationship between income and generosity did not hold true for Friends.

No other relationships between sex, age, income, or personality (including Extraversion) and welfare trade-off switch points reached statistical significance (Table 2; all p values > 0.05).

Study 2

Effect of MDMA on Welfare Trade-Off Task. Figure 3 shows the performance on the WTT as a function of MDMA dose and Person (Friend, Stranger). Similar to Study 1, participants were significantly more generous toward the Friend compared to the Stranger, regardless of MDMA dose (main effect of Person; $F(1, 30) = 22.2$; $p < 0.001$).

When the other person was the Friend, MDMA (1.0 mg/kg) significantly increased WTR switch points compared to placebo

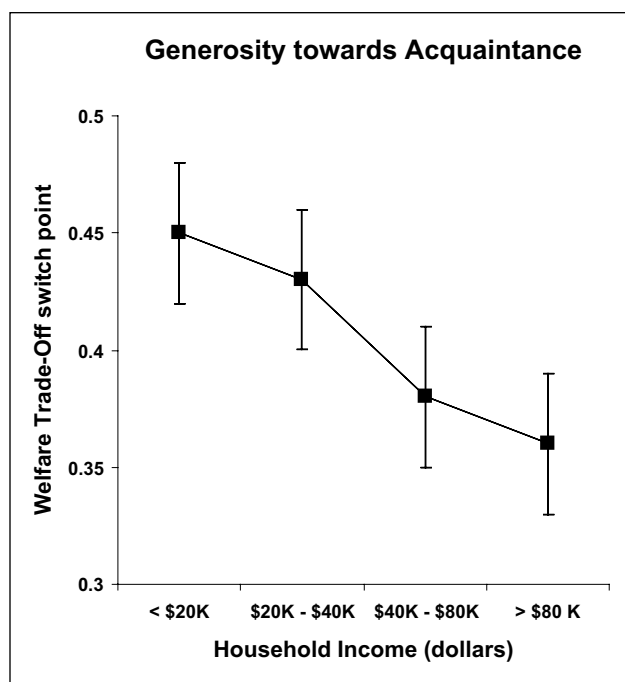


Figure 2. Mean (SEM) welfare trade-off ratio switch points for the Acquaintance as a function of household income group. Error bars represent one SEM.

(Dose \times Person interaction; $F(2,60) = 3.5$; $p < 0.05$; comparison between 1.0 mg/kg MDMA and placebo: $t(31) = 1.8$; $p < 0.05$), suggesting that MDMA increased generosity. That is, if their friend could receive \$100, participants would trade off up to \$57 following placebo administration and up to \$72 (\$15 more) following the larger MDMA dose. When the other person was the Stranger, MDMA (0.5 mg/kg) significantly increased the WTR switch points in women but not men (Dose \times Sex quadratic interaction; $F(1,30) = 4.8$; $p < 0.05$; women: mean difference between 0.5 mg/kg MDMA and placebo = 0.25 ± 0.11 ; 95% CI 0.03–0.48; $p < 0.05$; men: mean difference = 0.04 ± 0.07 ; 95% CI -0.10–0.18; $p = 0.56$). There were no other significant effects of sex on drug response (all p values $> .05$).

Discussion

These analyses with the WTT provided several interesting findings. As expected, participants were more generous with a close friend than an acquaintance or stranger. Interestingly, however, in Study 1 generosity on the WTT was negatively correlated with household income. That is, participants reporting higher incomes were *less* likely to share money with acquaintances than were participants with lower incomes. Household income was not related to generosity toward a close friend. We found that participants high on the personality trait of Agreeableness were more generous toward both close friends and acquaintances. In Study 2 we found that MDMA (1.0 mg/kg) increased generosity toward a friend, but not toward a stranger, whereas the lower dose (0.5 mg/kg) did not affect generosity toward the friend but slightly increased generosity toward a stranger. Taken together, the results extend our knowledge of the behavioral trait of generosity, and

show that the WTT may be a useful measure in future drug studies of prosocial behavior.

In Study 1, generosity was negatively related to household income and positively related to the personality measure of trait Agreeableness. The negative relationship to income may be intuitively paradoxical, but it is consistent with previous reports that individuals with lower socioeconomic status may be more generous than those with higher socioeconomic status (Piff 2014; Piff et al., 2010). For example, Piff (2014) reported that upper-class individuals (defined by parental educational attainment) reported greater psychological entitlement and narcissistic personality tendencies, and the authors concluded that social stratification contributes to basic psychological processes. The positive relationship between generosity and agreeableness is consistent with previous research (Ashton et al., 1998) and intuitively more direct, and suggests that a positive disposition also has behavioral consequences on willingness to share financial resources. It is also notable that the closely related personality trait of Extraversion did not predict WTRs; this speaks to the specificity of the construct captured by the WTT. One limitation of Study 1, however, is that the sample was relatively homogeneous, consisting of Caucasian young adults with a high school education and no serious psychiatric symptomatology. It is not known whether these findings would generalize to a more heterogeneous population.

We also found that MDMA increased generosity, and that this effect depended on the dose and on the relational closeness of the other recipient. When participants had the opportunity to give money to either themselves or a close friend, the larger dose of MDMA increased generosity toward the other person, whereas when the other person was a stranger, the larger dose did not produce this effect. The increase in generosity observed here is consistent with earlier reports that MDMA increases “prosocial” resource allocation and emotional empathy (Hysek et al., 2014; Wardle and de Wit, 2014). In our study, the most pronounced increase in generosity was observed after the higher dose of MDMA, and only in relation to a close friend, not a stranger.

This finding is strikingly concordant with a recent report on the effects of oxytocin, a neuropeptide involved in social bonding and thought to be related to responses to MDMA (Hysek et al., 2012; Kirkpatrick et al., 2014a). In addition to its actions of serotonin and norepinephrine release, MDMA increases levels of oxytocin, and these effects are thought to contribute to its empathogenic effects (Thompson et al., 2010). Intranasal oxytocin itself can increase prosocial behavior, dependent upon on the context in which it is experienced (see Bartz et al., 2011 for a review). For example, oxytocin promotes trust of people who are members of a social in-group but does not affect trust of out-group members (De Dreu et al., 2010; see Van IJzendoorn and Bakermans-Kranenburg, 2012 for a review). This relationship is consistent with our observation that MDMA (1.0 mg/kg) increased generosity toward the close friend but not toward the stranger. It is not clear why the drug at the lower dose slightly increased generosity to the stranger. The differences in dose effects may be related to the potency of the drug to release oxytocin or serotonin, which is also involved in prosocial behaviors (Crockett et al., 2010), or may reflect a relatively non-specific drug effect at the low dose. Future studies may examine whether the increases in generosity are indeed related to oxytocin levels, or whether these similar effects occur with other drugs, such as the related stimulant amphetamine or the sedative diazepam. It is also possible that the prosocial effects of MDMA endure even after

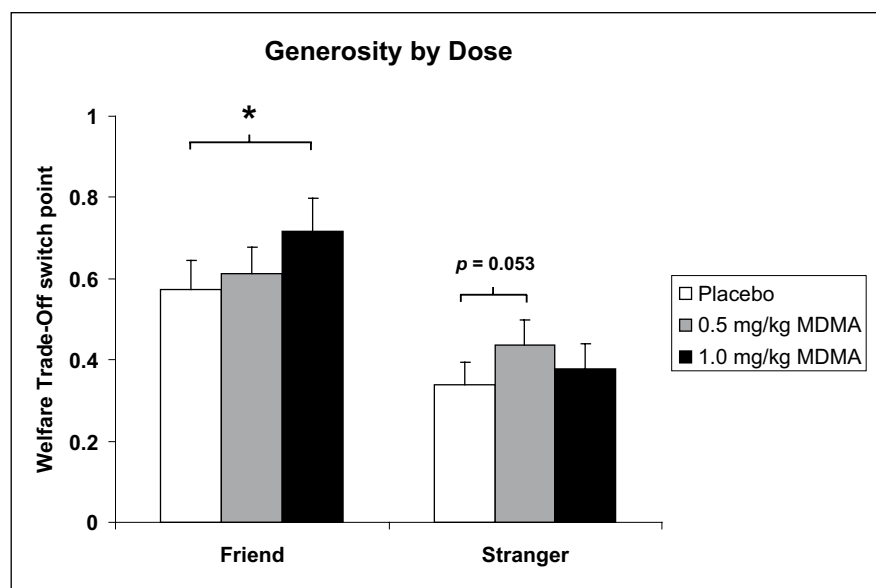


Figure 3. Mean (SEM) welfare trade-off ratio switch points for the Friend and Stranger as a function of MDMA dose. *indicates 1.0 mg/kg MDMA dose significantly different from placebo ($p < 0.05$). Error bars represent one SEM.

plasma levels return to baseline, as recent clinical studies indicate that MDMA plus psychotherapy produces long-lasting improvements in PTSD symptoms and social relationships (Mithoefer et al., 2011, 2013). In the present study there was no evidence that drug order (i.e. administration of drug or placebo in a previous session) affected responses, but this remains a subject of interest.

Interestingly, the increase in generosity toward the stranger occurred primarily in women. Although this sex difference is consistent with at least one previous report indicating that MDMA may produce more intense psychoactive effects in women compared to men (Liechti et al., 2001), it is inconsistent with the previous MDMA study showing that increases in monetary resource allocation occurred primarily in men (Hysek et al., 2014). Differences in dose or task design and our relatively small sample size could explain the apparent discrepancy between the finding of Hysek et al. and ours. Future investigations of the prosocial effects of MDMA may confirm whether these effects differ by sex. Considering that menstrual cycle phase and its associated alterations in sex hormone concentrations are associated with changes in oxytocin levels (Salonia et al., 2005), stimulant response (White et al., 2002), and prosocial behaviors such as empathy (Derntl et al., 2013), it is possible that fluctuations in sex hormone levels substantially alter the prosocial effects of MDMA in women.

In conclusion, we demonstrate the value of the WTT in assessing a novel behavioral construct, that of generosity to others. Generosity to friends or strangers plays an important role in social structures and in the functioning of individuals within a group. The fact that generosity was related to both socioeconomic status and to the personality trait of Agreeableness adds to our understanding of individual differences in the measure. The fact that MDMA increased generosity is consistent with some of its anecdotal prosocial effects, and may be related to its purported mechanism via release of oxytocin. The task is likely to be useful in future studies investigating the prosocial effects of MDMA and other drugs of abuse that are used to enhance social behavior. Considering that MDMA's prosocial effects may be

an important factor in its abuse potential (Bravo, 2001; Sumnall et al., 2006), this task may help to identify social factors that increase the reward value of abused drugs.

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